

Mollusca Gastropoda : Columbariform Gastropods of New Caledonia

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ABSTRACT

A survey of the deep-water malacofauna of New Caledonia has brought to light two species referable to the subfamily Columbarinae (Gastropoda: Turbinellidae). *Coluzea faceta* sp. nov. is described from off the Isle of Pines at depths of 385-500 m. Additional specimens of *Coluzea piniicola* Darragh, 1987, previously described from off the Isle of Pines, serve as the basis for the description of the new genus

Fustifusus. *Serratifusus virginiae* sp. nov. and *Serratifusus lineatus* sp. nov., two Recent species of the columbariform genus *Serratifusus* Darragh, 1969, previously known only from deep-water fossil deposits of Miocene age, are also described. On the basis of anatomical and radular data, *Serratifusus* is transferred from the Columbarinae to the family Buccinidae.

RÉSUMÉ

Mollusca Gastropoda : Gastéropodes columbariformes de Nouvelle-Calédonie.

Au cours des campagnes d'exploration de la faune profonde de Nouvelle-Calédonie, deux espèces de la sous-famille Columbarinae (Gastropoda : Turbinellidae) ont été découvertes. *Coluzea faceta* sp. nov. est décrite du large de l'île des Pins entre 385 et 550 m. *Coluzea piniicola* Darragh, 1987,

également décrite de l'île des Pins, a été récoltée vivante et devient l'espèce type du nouveau genre *Fustifusus*. Le genre *Serratifusus* Darragh, 1969 n'était jusqu'ici connu que de dépôts miocènes en faciès profond : deux espèces actuelles, *S. virginiae* sp. nov. et *S. lineatus* sp. nov., sont maintenant décrites de Nouvelle-Calédonie. Sur la base des caractères anatomiques et de la radula, le genre *Serratifusus* est transféré des Columbarinae à la famille des Buccinidae.

INTRODUCTION

The Columbariinae is the most speciose of the subfamilies of Turbinellidae, with nearly 50 Recent species inhabiting bathyal depths along continental margins, predominantly in tropical and temperate latitudes (HARASEWYCH, 1986). These animals inhabit soft substrates and feed on tube-dwelling polychaete worms (HARASEWYCH, 1983). Earliest fossil representatives occur in the Late Cretaceous (Maestrichtian) deposits of Europe (DARRAGH, 1969). During the Paleogene, the Columbariinae were represented in shallow water (upper continental shelf) faunas ranging from western North America, throughout Europe, to New Zealand (DARRAGH, 1969). The few Neogene records are limited to deeper-water (outer continental shelf — upper continental slope) fossil deposits of southeastern Australia and New Zealand (DARRAGH, 1969; FINLAY, 1930), dating the shift in their habitat from subtidal to bathyal depths. Diverse columbariine faunas have long been known to occur in the western Atlantic (CLENCH, 1944, 1959; BAYER, 1971; HARASEWYCH, 1983), western Indian

(MARTENS, 1901; TOMLIN, 1928; BARNARD, 1959), and western Pacific (HABE, 1979; DARRAGH, 1987; POWELL, 1979) Oceans. More recently, columbariines have been discovered along continental margins of the eastern Pacific (MCLEAN & ANDRADE, 1982) and eastern Indian (HARASEWYCH, 1986) Oceans.

Dr Philippe BOUCHET, Curator of Marine Mollusca, Muséum national d'Histoire naturelle, Paris, has kindly made available specimens of columbariform gastropods dredged and trawled in the upper bathyal zone off New Caledonia as part of an ongoing faunal sampling program. The purpose of this paper is to report on this material, which contained: a new species of *Coluzea*; adult specimens and anatomical material of the recently described *Coluzea pinicola* Darragh, 1987, that serve as the basis for a description of a new genus; and two new Recent species referable to the genus *Serratifusus*, previously known only from Early to Middle Miocene horizons (DARRAGH, 1969, 1985).

MATERIALS AND METHODS

The present study is based primarily on specimens collected by the vessels R.V. "Vauban" and R.V. "Jean-Charcot" during BIOCAL, MUSEORSTOM 4, LAGON, CHALCAL 2, and SMIB 4 cruises. For a narrative of the deep-sea cruises and list of stations, see RICHER de FORGES (1990).

Where sufficient specimens were available, material for anatomical studies was obtained by fracturing the shells in a vice, removing larger fragments with forceps, and dissolving remaining shell with 10% hydrochloric acid (HCl). Soft parts were rinsed in distilled water and transferred to 70% ethanol for dissection. Protoconchs and radulae were cleaned in dilute Sodium hypochlorite solution (1% NaOCl) prior to ex-

amination with SEM. All scanning electron micrographs were taken using a Hitachi S-570 SEM.

Repositories of examined specimens are indicated by the following abbreviations:

- AMS — Australian Museum, Sydney
- BM(NH)G — British Museum of Natural History, Geology Department, London
- DMNH — Delaware Museum of Natural History, Wilmington
- MNH — Muséum national d'Histoire naturelle, Paris
- NMNZ — National Museum of New Zealand, Wellington
- USNM — National Museum of Natural History, Smithsonian Institution, Washington, DC

SYSTEMATIC ACCOUNT

Family TURBINELLIDAE Swainson, 1840
Subfamily COLUMBARIINAE Tomlin, 1928

Genus *COLUZEA* Allan, 1926

Coluzea Allan, 1926: 304, issued separately December 7, 1926.

Type species: *Fusus dentatus* Hutton, 1877, by monotypy.

Coluzea Finlay, 1926: 407, issued separately December 23, 1926.

Type species: *Fusus spiralis* A. Adams, 1856, by original designation.

The morphological similarities between the genera *Coluzea*, and *Fulgurofusius* Grabau, 1904, have been discussed previously (FINLAY, 1930: 267-268; HARASEWYCH, 1983: 5, 1986: 158). Full generic status is provisionally retained for *Coluzea* until a revision of the subfamily can be

completed. *Coluzea* first appears in the Eocene deposits of the Paris and London Basins, and is known from the Late Oligocene of New Zealand (DARRAGH, 1969). As presently understood, the genus appears to be restricted in the Recent fauna to continental margins in the temperate and tropical regions of the Indian Ocean, to the eastern margin of the Australian tectonic plate, and to those adjacent regions of the Pacific tectonic plate west of the Andesite Line (see SPRINGER, 1982: fig. 2). A request for a ruling by the International Commission on Zoological Nomenclature on the authorship and type species of *Coluzea* (BEU *et al.*, 1969) is still pending.

Coluzea faceta sp. nov.

Figs 1-4, 22; Table 1

MATERIAL EXAMINED. — New Caledonia. "*Vauban*", 1978: stn 14, 22°16'S, 167°17'E, 465-495 m, 23-28.05.1978: paratype 10, 49.5 mm, MNHN.

MUSORSTOM 4: stn 239, 22°14.80'S, 167°15.70'E, 470-475 m, 2.10.85: paratype 9, 58.5 mm, MNHN.

Stn 242, 22°05.80'S, 167°10.30'E, 500-550 m, 3.10.1985: holotype 82.6 mm, MNHN. — Stn 247,

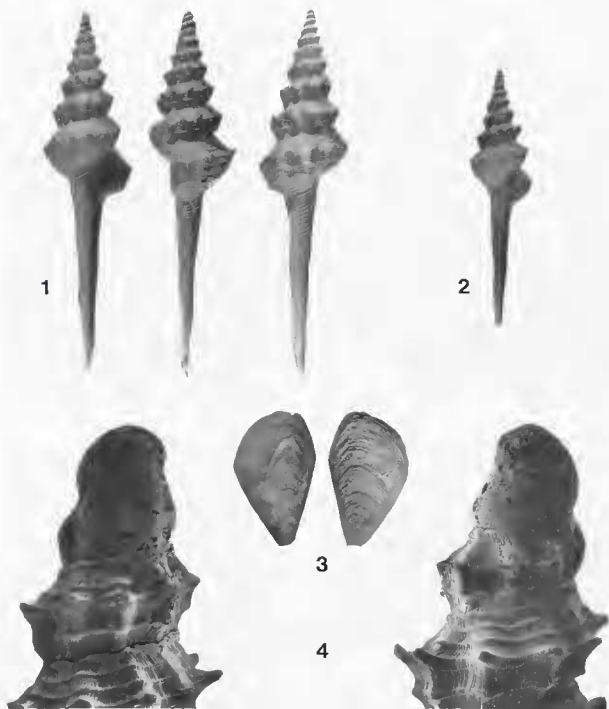
22°09.00'S, 167°13.30'E, 435-460 m, 4.10.1985: paratypes 1-2, 44.7 mm, 43.7 mm, USNM 860477; paratypes 3-5, 50.0 mm, 39.5 mm, 23.6 mm, MNHN; paratype 6,

38.1 mm, AMS. — Stn 248, 22°09.50'S, 167°10.00'E, 380-385 m, 4.10.1985: paratype 7, 57.4 mm, MNHN; paratype 8, 43.4 mm, MNZN.

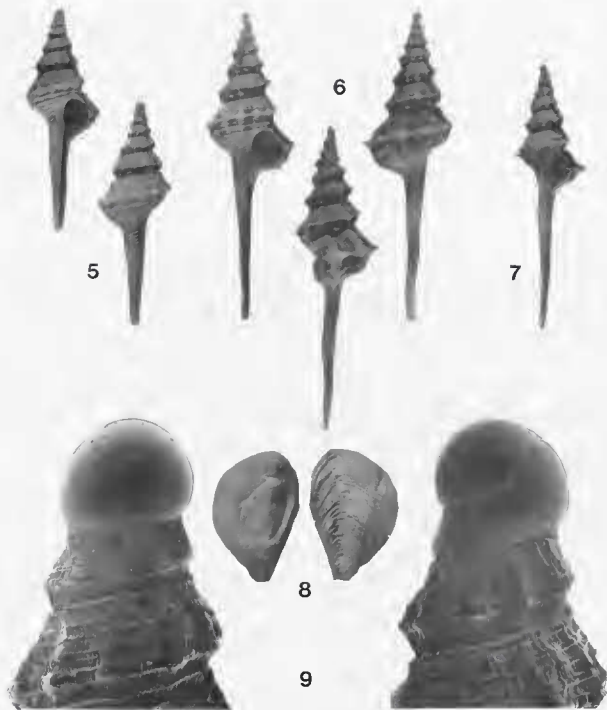
TYPE MATERIAL. — Holotype, MNHN; paratypes 1-2, USNM 860477; paratypes 3-5, 7, 9, 10, MNHN; paratype 6, AMS; paratype 8, MNZN.

TYPE LOCALITY. — Off southeastern New Caledonia, 22°05.80'S, 167°10.30'E, in 500-550 m. [MUSORSTOM 4, stn 242].

DESCRIPTION. — *Shell* (Figs 1-2) large (to 83 mm), heavy, fusiform; spire angle 28°-37°; protoconch (Fig. 4) of 1 1/4 whorls, with first whorl deflected from coiling axis by about 80°; transition to teleoconch marked by appearance of keeled axial ribs, followed within 1 whorl by spiral cords above and below shell periphery; teleoconch with up to 10 convex, weakly shouldered whorls; suture adpressed; axial sculpture of 9-10 hollow ribs on early postnuclear whorls, 10-11 thick, solid varices with short, open spines along periphery on sixth and subsequent whorls; spiral sculpture of 4-5 strong cords between suture and shoulder, 4-5 between shoulder and anterior carina, 4-5 between anterior carina and base of siphonal canal, 32-38 cords on proximal 2/3 of siphonal canal; 1-4 fine threads between adjacent spiral cords; second, and occasionally first spiral cord anterior to periphery particularly



FIGS 1-4. *Coluzea jaceta* sp. nov. : 1. Holotype, MNHN, MUSORSTOM 4, stn 242. Apertural, lateral and dorsal views. (0.775 x). 2. Paratype 7, MNHN, MUSORSTOM 4, stn 248. Apertural view. (0.775 x). 3. Operculum of paratype 7. (3.1 x). 4. Protoconch and first teleoconch whorl, paratype 5, MNHN, MUSORSTOM 4, stn 247. (24.8 x).



Figs 5-9. *Fastifusus pinicola* (Darragh, 1987): 5. Juvenile specimen of the same size as the holotype, MNHN, SMIB 4, stn 8. Apertural and dorsal views. (1.86x). 6. Adult specimen, MNHN, BIGCAL, stn 42. Apertural, lateral and dorsal views. (1.24 x). - 7. Sub-adult specimen, MNHN, "Vauban", 1978, stn 4. Apertural view. (1.24 x). 8. Operculum of specimen in figure 2. (4.34 x). 9. Protoconch and first teleoconch whorl, "Vauban", 1978 stn 4. (24.8 x).

pronounced, giving posterior portions of axial ribs angular, banded appearance; aperture ovate; outer lip thick, furrowed beneath periphery, inner lip smooth; siphonal canal 1/2 shell length, axial, stout, slightly sinuate distally; shell color white; periostracum thin, yellowish, consisting of series of fine, axial, blade-like lamellae; operculum (Fig. 3) thin, amber-colored, strongly ovate, with sharply tapered terminal nucleus.

TABLE 1. *Coluzea faceta* sp. nov. Measurements of shell characters. Linear measurements in mm. $n = 10$.

Character	\bar{X}	Range	SD
Shell length	47.9	23.6-82.6	14.7
Aperture length	7.4	3.6-12.6	2.2
Aperture length			
Shell length	0.16	0.14-0.17	0.01
Siphonal canal length	23.7	15.6-40.4	7.3
Siphonal canal length			
Shell length	0.49	0.41-0.55	0.05
No. whorls teleoconch	7.8	7.0-10.0	1.2
No. varices, body whorl	11.2	10-13	0.9
Spire angle	32.8°	28°-37°	2.5°

Animal: One male (paratype 9) and two female (holotype and paratype 7) specimens were dissected. Mantle cavity spanned about 3/4 whorl, kidney, 1/3 whorl, digestive gland not preserved; animal uniform tan in color; foot rectangular ($L/W = 2.0$); tentacles short; eyes absent or unpigmented; mantle edge thickened; osphradium short, broad ($L/W = 3.0$), with 65 leaflets above and 50 below axis; ctenidium 1.2 times as wide, 2.5 times as long as osphradium, with about 450 leaflets; hypobranchial gland transversely pleated; rectum long, narrow; rectal gland along anterior 1/3 of rectum; anus attached to roof of mantle cavity, with short ventral papilla; extended proboscis 1.1 times shell length; radula (Fig. 22) short (2 mm), narrow (110 μ m), with 105-133 rows of teeth ($n = 3$); lateral teeth monocuspid, with broad basal plate; rachidian teeth tricuspid, with laterally expanded basal plates; valve of Leiblein large, completely containing region of oesophageal torsion; salivary glands asymmetrical, adhering to each other and to oesophagus; salivary ducts enter oesophagus anterior to valve of Leiblein, becoming embedded beneath dorsal folds; gland of Leiblein large, occupying posterior 1/2 of cephalic sinus, situated to left and below proboscis sheath; posterior

oesophagus, broad, sacculate along gland of Leiblein, constricting at rear of cephalic sinus; stomach simple, U-shaped; rectum broad posteriorly, tapering anteriorly; female pallial gonoduct with long, tall capsule gland; bursa copulatrix ovate, anterior to capsule gland; male pallial gonoduct of simple narrow duct descending to floor of mantle cavity at mid-length to form deep, open, muscular groove lined with glandular tissue, running along inner edge of short, dorsoventrally-flattened penis; penis with glandular pad at distal end, without papilla; nervous system highly concentrated, with circumoesophageal ganglia fused.

ETYMOLOGY. — *L. facetus*, well made, elegant.

DISTRIBUTION. — This species is known from 5 stations, all off the southern tip of New Caledonia. The confirmed bathymetric range is 385-500 m, with a mean station depth of 461.5 m. Living specimens were taken at all stations except "Vauban" 1978, station 14.

ECOLOGY. — Little is known of the habitat of this species, other than the bathymetric range. Nearly all specimens have more than one repaired shell break, indicating frequent, unsuccessful predation by crabs and/or fish. All cases of shell breakage were limited to two varices or less (< 1/5 whorl), testifying to the effectiveness of the thickened costae as antipredatory adaptations. None of the specimens had been drilled.

COMPARATIVE REMARKS. — *Coluzea faceta* is conchologically most similar to *Coluzea distephanotis* (Melvill, 1891), but may be distinguished from this and the other Recent Western Australian and New Zealand species of *Coluzea* by its heavier shell, coarse spiral sculpture, and its pronounced and thickened axial costae. The lack of a canalliculate suture differentiates it from the Indonesian species *C. liriopae* Harasewych, 1986 as well as from the geographically most proximal *C. bimurata* Darragh, 1987, which inhabits shallower depths off Queensland. *Coluzea faceta* also resembles *C. angularis* (Barnard, 1959) from off South Africa, but differs in having short, open spines along the peripheral keel, and by the rounder shape of its aperture. When compared to the New Zealand species of *Coluzea*, *C. faceta* more closely resembles *C. paucispinosa* Finlay, 1930 and *C. dentata* (Hutton, 1877), both from the Miocene, than any younger species.

Genus *FUSTIFUSUS* gen. nov.

TYPE SPECIES. — *Coluzea pinicola* Darragh, 1987: 133-134, figs 4 E.I.

DESCRIPTION. Columbariinae with heavy, fusiform, high-spired shell of moderate size (to 46 mm); protoconch, glassy, inflated, deflected from coiling axis by about 60°, first whorl as large or larger than subsequent whorl; spiral sculpture predominating in early whorls, forming sutural canal by fourth or fifth post-nuclear whorl; axial sculpture increasing in prominence with increasing shell size, forming pronounced ribs or varices with open peripheral spines by seventh post-nuclear whorl; color light brown with bands of cream or white along periphery, at juncture of body whorl with siphonal canal, and along siphonal canal (Fig. 6); basal plate of rachidian tooth U-shaped (Fig. 24), but not laterally expanded.

ETYMOLOGY. Latin *fustus*, a knobbed stick, *fustus*, a spindle.

Fustifusus pinicola (Darragh, 1987)

Figs 5-9, 23-24; Table 2

Synonymy: *Coluzea pinicola* Darragh, 1987: 133-134, figs 4 E.I.

MATERIAL EXAMINED. — New Caledonia. "I'auhan", 1978: stn 4, 22°17'S, 167°13'E, 400 m, 23-28.05.1978: 3 specimens 37.0 mm, 26.6 mm, 14.5 mm, MNHN. — Stn 16, 22°46'S, 167°12'E, 390-400 m, 10-15.04.1978: 1 specimen 17.9 mm, MNHN.

LAGOON: stn 395, 22°48.2'S, 167°07.6'E, 313 m, 23.01.1985: 1 specimen 31.9 mm, MNHN. — Stn 419, 22°42.3'S, 167°10.5'E, 330 m, 24.01.1985: 1 specimen 23.5 mm, MNHN.

BIOCAL: stn 38, 22°59.74'S, 167°15.31'E, 360 m, 30.08.1985: 1 specimen 35.44 mm, MNHN. Stn 42, 22°45.14'S, 167°12.12'E, 380 m, 30.08.1985: 1 specimen 45.2 mm, MNHN. — Stn 44, 22°47.30'S, 167°14.30'E, 440-450 m, 30.08.1985: 7 specimens 20.8 mm, 19.4 mm, 19.3 mm, 19.2 mm, 19.0 mm, 17.8 mm, 16.6 mm, MNHN.

MUSORSTOM 4: stn 212, 22°47.40'S, 167°10.50'E, 375-380 m, 28.09.1985: 1 specimen 23.1 mm, MNHN. — Stn 226, 22°47.20'S, 167°21.60'E, 395 m, 30.09.1985: 3 specimens 41.2 mm, USNM 860478, 33.5 mm, 8.8 mm, MNHN. — Stn 227, 22°46.00'S, 167°20.00'E, 320 m,

COMPARATIVE REMARKS. The globose, strongly deflected protoconch, pigmented shell, and weak but distinct raised columellar plate indicate that this genus is more closely related to *Columbarium* than to any of the genera or subgenera in the *Coluzea* — *Filgurofusus* lineage. It differs from most Recent species of *Columbarium* in retaining the plesiomorphic high spire, in having broad, thickened varices, and a channeled suture, as well as in lacking numerous serrated spiral cords along the siphonal canal. The radula of the type species is unlike that of any known columbariine in having two usually well-defined but smaller cusps on either side of the three large cusps of the rachidian tooth. The recurved basal plate lacking laterally-expanded buttresses is a character shared with species of *Columbarium* [e.g. *Columbarium spinicinctum* (von Martens, 1881) see HARASEWYCH, 1983: fig. 11].

30.09.1985: 1 specimen 20.3 mm, MNHN. — Stn 230, 22°52.50'S, 167°11.80'E, 390-420 m, 30.09.1985: 3 specimens 25.4 mm, 21.1 mm, 15.4 mm, MNHN. — Stn 234, 22°15.50'S, 167°08.30'E, 350-365 m, 2.10.1985: 1 specimen 36.6 mm, USNM 860479.

SMB 4: stn 5, 22°56.3'S, 167°14.4'E, 398-410 m, 17.09.1986: 1 specimen 20.4 mm, MNHN. — Stn 8, 22°53.6'S, 167°12.5'E, 435-447 m, 18.09.1986: 1 specimen 21.1 mm, MNHN.

ca. 22°50'S, 167°15'E, 200-400 m: 3 specimens 40.4 mm, 35.2 mm, 24.13 mm, MNHN.

TYPE MATERIAL. — Holotype, AMS, C82163; paratype 1, AMS, C152010.

TYPE LOCALITY. South of Isle of Pines, New Caledonia, 22°50'S, 167°35.5'E, in 370 m, ["*Kimbla*" stn K4-71-4].

DESCRIPTION. — Shell (Figs 5-7) of medium size (to 46 mm), moderately heavy, fusiform; spire angle 28°-33.5°; protoconch (Fig. 9) of 1

whorl, glassy, rotund; first 1/2 whorl deflected from shell axis by about 60°, larger than subsequent whorl; transition to teleoconch gradual, marked by formation of peripheral keel, rounded at first, becoming progressively more acute; nodules develop along keel by second post-nuclear whorl, becoming short, open spines by fourth post-nuclear whorl; teleoconch with up to 7 convex whorls; suture adpressed; spiral sculpture of 3-4 cords between suture and periphery, 5-6 between periphery and siphonal canal, 20-28 on proximal 2/3 of siphonal canal; adsutural spiral cord increases in prominence, forming sutural canal by fourth post-nuclear whorl; axial sculpture of 8-16 low ribs per whorl, forming spines and nodes at intersections with peripheral keel and adjacent spiral cords, respectively; growth striae fine, sinuate; aperture strongly ovate to triangular; outer lip thick, glazed, furrowed beneath peripheral keel; inner lip smooth, with raised inductural edge extending length of siphonal canal in adult specimens; siphonal canal long, straight, stout; base color ginger to brown, with lighter bands along periphery and siphonal canal; aperture white, occasionally with brown band along outer lip; periostracum thin, ginger brown, with fine axial lamellae forming tufts along spiral cords and rim of sutural canal; operculum (Fig. 8) thin, amber-colored, rounded posteriorly, sharply tapered anteriorly, with terminal nucleus.

TABLE 2. *Fustifusus pinicola* (Darragh, 1987). Measurements of shell characters. Linear measurements in mm. N = 10.

Character	\bar{X}	Range	SD
Shell length	35.3	23.1-45.5	6.4
Aperture length	5.6	4.5-6.7	0.8
Aperture length			
Shell length	0.16	0.14-0.19	0.02
Siphonal canal length	16.9	9.4-23.4	4.5
Siphonal canal length			
Shell length	0.50	0.45-0.53	0.02
No. whorls teleoconch	6.9	6.0-7.3	0.4
No. varices, body whorl	10.4	8-13	1.3
Spire angle	31.3°	28°-33.5°	1.5°

Animal: Two dried male specimens were rehydrated and dissected. Foot long, narrow, rectangular ($t/w = 2.2$); tentacles short, blunt, with large black eyes; mantle cavity narrow, of 1 1/4

whorl; osphradium large, broad, ctenidium equal in width to osphradium; hypobranchial gland whitish, globular, 1 1/2 times as wide as ctenidium; penis short, narrow, blunt, with open sperm groove; proboscis long, folded within proboscis sheath; buccal mass minute; radula (Figs 23, 24) short (980 μm), narrow (60 μm), consisting of 102-118 rows ($n = 2$); basal plate of rachidian tooth U-shaped, with 1-2 short cusps on either side of 3 long central cusps; lateral teeth with single, long, scythe-shaped cusps.

ETYMOLOGY. — Named after the type locality, the Isle of Pines.

DISTRIBUTION. — This species has been collected at 15 stations, all off the Isle of Pines. The confirmed bathymetric range for live-collected specimens is 330-440 m. Specimens inhabited by hermit crabs have been taken as shallow as 300 m. The mean station depth for all records is 373.2 m.

ECOLOGY. — This species inhabits soft substrates at depths of 330 to 440 meters, and co-occurs with *Serratifusus virginiae* sp. nov., described below, at 6 of the 15 stations. Polychaete setae were found in the rectum of one specimen of *Fustifusus pinicola*.

COMPARATIVE REMARKS. — This species was originally described in the genus *Coluzea*, based on the morphology of two immature specimens (DARRAGH, 1987). Although juvenile specimens of *Fustifusus pinicola* resemble New Zealand Miocene species of *Coluzea* in having high-spired shells with strong spiral sculpture and weak tubercles along the keel, these characters are probably symplesiomorphic within Columbariinae and therefore not indicative of close phylogenetic relationships. The globose protoconch, weakly raised columellar plate, and diffuse brown coloration present in this species are characters that occur in most western Pacific Columbariinae species, but not in species *Coluzea* or *Fulgurofusus*. The thickened varices that generally do not appear until the seventh post-nuclear whorl also occur in *Columbariina natalense* Tomlin, 1928, a species that inhabits shallower (90-200 m) depths off southeastern Africa.

Family BUCCINIDAE Rafinesque, 1815
Subfamily BUCCININAE Rafinesque, 1815

Genus *SERRATIFUSUS* Darragh, 1969

Serratifusus Darragh, 1969: 89

TYPE SPECIES. — *Fusus craspedotus* Tate, 1888, by original designation.

In his revision of the family Columbariidae, DARRAGH (1969: 90) proposed the genus *Serratifusus* for a group of closely related fossil species that: have prominent axial sculpture on the final whorl of the protoconch, have axial ribs on early teleoconch whorls, have a pronounced peripheral keel with open spines, and that lack a curved lamella on the columellar lip. He recognized that this genus differed from *Columbarium*, but retained it in the then family Columbariidae on the basis of the conchological resemblance to *Coluzea*. *Serratifusus* was believed to be restricted to Early to Middle Miocene deposits of southeastern Australia and Tasmania (DARRAGH, 1969, 1985).

A newly discovered Recent species, described below, closely resembles *Serratifusus craspedotus* (Tate, 1888), the type species of *Serratifusus*, in features of shell and protoconch, and exhibits all the diagnostic characters of this genus. Thus, the stratigraphic range of *Serratifusus* is extended to the Recent. An examination of the anatomical organization of the Recent species reveals that *Serratifusus* is more properly assigned to the family Buccinidae. Tricuspid rachidian teeth with a rectangular basal plates, tricuspid lateral teeth, a narrow, sacculate gland of Leiblein, a closed

vas deferens, a penis with a closed sperm duct, and the lack of a rectal gland are among the characters that support the transfer of the genus to the Buccinidae, and suggest that *Serratifusus* is closely related to *Penion* Fischer, 1884 (see PONDER, 1973).

In discussing the type species of *Serratifusus*, (as *Fusus craspedotus*) HARRIS (1897: 54, 135) commented on its resemblance to "certain forms of *Columbarium*", but assigned it to the family Fascioliariidae on the basis of protoconch morphology. *Serratifusus youngi* (Chapman, 1922) was provisionally included in *Serratifusus*, but may prove to be referable to *Fusinus* (DARRAGH, 1969: 92). The eight remaining species originally included in *Serratifusus* (DARRAGH, 1969) most likely represent a monophyletic assemblage within the Buccinidae.

Serratifusus appears most closely related to *Penion* based on general conchological similarity as well as nearly identical anatomical organization and radular morphology (PONDER, 1973). *Serratifusus* may be distinguished from *Penion*, however, by its smaller, thinner shell, longer siphonal canal, and by its sharply angled periphery with prominent radial spines. *Serratifusus* and *Penion* are found together in Early to Middle Miocene beds (DARRAGH, 1989, personal communication). In the Recent fauna, *Serratifusus* is restricted to bathyal depths, while *Penion* occurs in shallower waters along the continental slope.

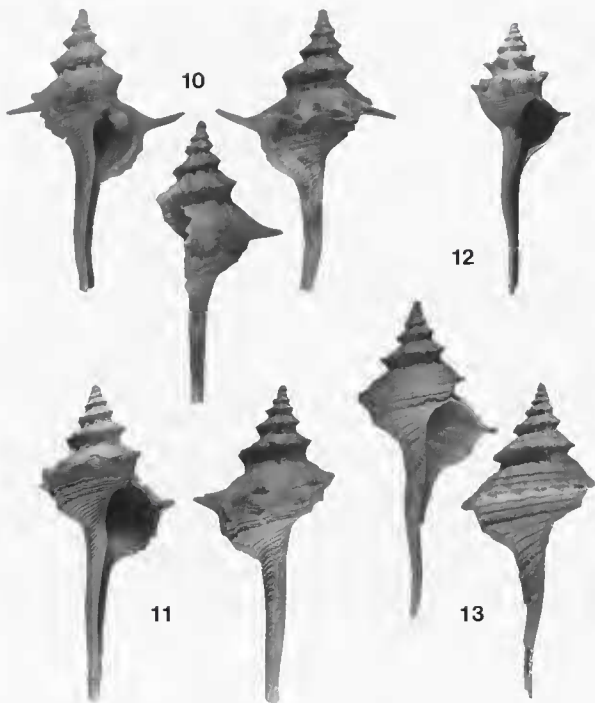
Serratifusus virginiae sp. nov.

Figs 10-12, 17, 19, 25; Table 3.

MATERIAL EXAMINED. — New Caledonia. "Vauban", 1978: stn 16, 22°46'S, 167°12'E, 390-400 m, 10-15.04.1978: paratype 2, 40.5 mm, MNHN.

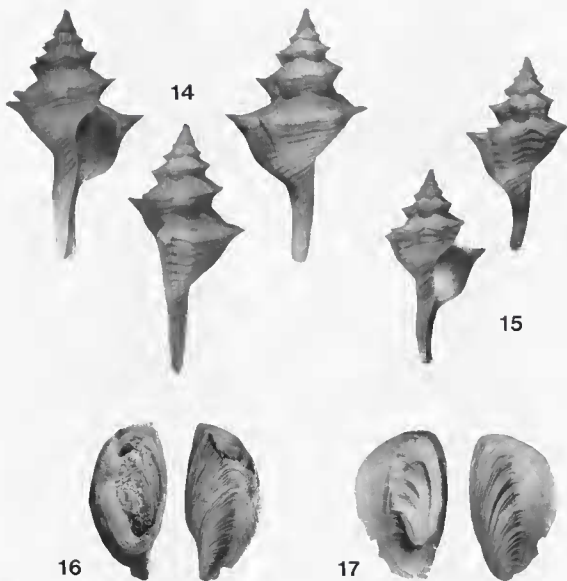
MUSORSTOM 4: stn 212, 22°47.40'S, 167°10.50'E, 375-380 m, 28.09.1985: holotype, 40.7 mm, MNHN; paratype 1, 45.2 mm, USNM 860480. Stn 226,

22°47.20'S, 167°21.60'E, 395 m, 30.09.1985: paratypes 3-4, 34.9 mm, 28.9 mm, MNHN. — Stn 227, 22°46.00'S, 167°20.00'E, 320 m, 30.09.1985: paratype 5, 35.6 mm, AMS; paratype 6, 32.8 mm, MNHN. — Stn 234, 22°15.50'S, 167°08.30'E, 350-365 m, 2.10.1985: paratypes 7-8, 39.0 mm, 30.7 mm, MNHN.



FIGS 10-12. *Serratifusus virgatae* sp. nov. : **10**. Holotype, MNHN, MUSORSTOM 4, stn 212. Apertural, lateral and dorsal views. (1.24 x) **11**. Paratype 1, USNM 860480, MUSORSTOM 4, stn 212. Apertural and dorsal views. (1.24 x). **12**. Paratype 7, MNHN, MUSORSTOM 4, stn 234. Apertural view. (1.24 x).

FIG. 13. *Serratifusus craspedotus* (Tate, 1888). BM(NH) G.38761-5, Muddy Creek near Hamilton, Victoria, Australia, Balcombian (Middle Miocene). Apertural and dorsal views (1.24 x).



FIGS. 14-16. *Serratifusus lineatus* sp. nov. : 14, Holotype, MNHN, MUSORSTOM 4, sin 181. Apertural, lateral and dorsal views (1.24 x). 15, Paratype 1, USNM 860843, MUSORSTOM 4, sin 181, apertural and dorsal views. (1.24 x). 16, Operculum of holotype of *Serratifusus lineatus* sp. nov. (3.1 x).

FIG. 17 = *Serratifusus virginiae* sp. nov. . Holotype, MNHN, MUSORSTOM 4, sin 212. Operculum.

CHALCAL 2: stn 81, 23°19.60'S, 168°03.40'E, 311 m, 31.10.1986: paratype 10, 38.2 mm, NMNZ; paratypes 11-12, 19.4 mm, 18.5 mm, USNM 860481. — Stn 82, 23°13.68'S, 168°04.27'E, 304 m, 31.10.1986: paratypes 13-14, 31.0 mm, 30.7 mm, MNHN.

From fishing boat, ca. 22°50'S, 167°15'E, 200-400 m: paratype 9, 31.7 mm, MNHN.

TYPE MATERIAL. — Holotype, MNHN; paratype 1, USNM 860480; paratypes 2-4, MNHN; paratype 5, AMS; paratypes 7-9, MNHN; paratype 10, NMNZ; paratypes 11-12, USNM 860481; paratype 13-14, MNHN.

TYPE LOCALITY. West of the Isle of Pines, New Caledonia, 22°47.40'S, 167°10.50'E, in 375-380 m. [MUSORSTOM 4, stn 212].

DESCRIPTION. — *Shell* (Figs 10-12) large (to 46 mm), thin, fusiform; spire angle 45-55°; protoconch (Fig. 19) of 1 1/2 inflated whorls, first whorl deviated from coiling axis by 45°; transition to teleoconch marked by smooth axial ribs with knobs along periphery becoming gradually more pronounced, forming short, broad, open spines by third postnuclear whorl; teleoconch with up to 6 inflated, sharply shouldered whorls; suture adpressed; spiral sculpture weak, area between suture and peripheral keel smooth, with weak threads along spines; body whorl below periphery with 19-21 cords; cords equally broad posteriorly, gradually differentiating into alternating broad and narrow cords anteriorly; 36-38 alternating broad and narrow spiral cords on proximal 2/3 of siphonal canal; axial sculpture of 6-8 ribs on early whorls, forming broad spines on later whorls; growth striae very fine, strongly sinuate; aperture subtriangular; outer lip furrowed beneath peripheral keel; inner lip smooth; siphonal canal long, slightly sinuate; shell color light tan to ginger, with white blotches on spines and reddish brown blotches most strongly pronounced between suture and periphery and along siphonal canal; aperture white to light tan; periostracum thin, amber-colored, axially lamellate; operculum (Fig. 17), broadly oval, with terminal nucleus and median ridge.

Animal: One male (paratype 5) and two female (holotype and paratype 1) specimens were dissected. Soft parts span 2 1/2 whorls, mantle cavity 1/2 whorl, kidney 1/4 whorl, digestive gland 1 1/2 whorls; animal yellowish tan, with

TABLE 3. *Serratifusus virginiae* sp. nov. Measurements of shell characters. Linear measurements in mm, $n = 9$

Character	\bar{X}	Range	SD
Shell length	34.8	17.3-45.2	7.8
Aperture length	8.8	6.1-11.8	2.7
<u>Aperture length</u>			
Shell length	0.25	0.19-0.32	0.04
Siphonal canal length	15.4	8.6-21.3	4.2
<u>Siphonal canal length</u>			
Shell length	0.44	0.36-0.53	0.07
No. whorls teleoconch	5.0	3.5-5.75	0.6
No. varices, body whorl	10.2	8-12	1.1
Spire angle	49.6°	45.5°-55.0°	3.2°

fine black spots on head, foot; foot broad ($t/w = 1.2$); tentacles short, broad; eyes large, black; mantle edge thin, smooth; osphradium long, broad ($L/W = 3.2$), with 97 leaflets above and 78 leaflets below axis; ctenidium equally long, 1 3/4 times as wide as osphradium, with about 280 leaflets; hypobranchial gland narrower than ctenidium; rectum broad posteriorly, tapering anteriorly; rectal gland absent; anus pendant; extended proboscis about 0.4 times shell length; radula (Fig. 25) short (2 mm), narrow (80 μ m), of 90-112 rows of teeth ($n = 3$); lateral teeth tricuspid, outermost cusp longest, emanating from near center of basal plate, central cusp shortest, thinnest; rachidian teeth tricuspid, central cusp longest, basal plate deep, rectangular; valve of Leiblein large, anterior to region of esophageal torsion; salivary ducts paired, surrounding valve of Leiblein and nerve ring; gland of Leiblein, thin, brown, situated along left side of retracted proboscis; stomach simple, tubular; female pallial gonoduct comprised of albumen gland, situated along right side of kidney, large ingesting gland, long, narrow capsule gland, and large, muscular, anteriorly situated bursa copulatrix; male pallial gonoduct consists of closed muscular duct of uniform diameter, glandular along posterior 3/4 of length, leading from rear of mantle cavity to base of penis; penis short (1/2 mantle cavity length), distally broad, dorsoventrally compressed, with short papilla along truncated distal outer edge; nervous system highly concentrated.

ETYMOLOGY. — This species honors Ms Virginie Héros for her work in processing much of



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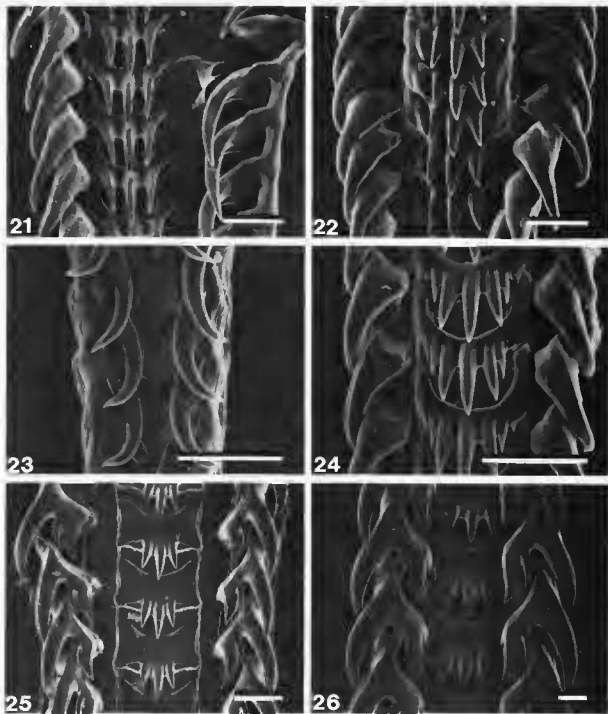
19



20



FIGS. 18-20. — Protoconch and early teleoconch whorls of species of *Serratifusus*. All views 15.5 x: **18**, *Serratifusus craspedotus* (Late, 1888), BM(NH) G.38761-5, muddy Creek near Hamilton, Victoria, Australia, Balcombian (Middle Miocene). — **19**, *Serratifusus virginiae* sp. nov., MUSORSTOM 4, sta 227. — **20**, *Serratifusus lineatus* sp. nov., MUSORSTOM 4, sta 181.



- Radulae Oriented with anterior end toward top of the page. All scale bars = 25 μ m.
- FIG. 21. *Coluzea spiralis* (A. Adams, 1856) DMNH 48393, Off Kawanu Id., North Island, New Zealand.
- FIG. 22. *Coluzea faceta* sp. nov. Holotype, MNHN, MUSORSTOM 4, stn 242.
- FIG. 23-24. *Fustifusus pinicola* (Darragh, 1987), USNM 860479, MUSORSTOM 4, stn 234 ;
23. Radula in retracted orientation, with lateral teeth folded over rachidian teeth.
24. Radula in extended, rasping orientation, with lateral teeth unfolded.
- FIG. 25. *Serratifusus virginiae* sp. nov. Holotype, MNHN, MUSORSTOM 4, stn 212.
- FIG. 26. *Serratifusus lineatus* sp. nov. Holotype, MNHN, MUSORSTOM 4, stn 181.

the deep-water expedition material collected off New Caledonia.

DISTRIBUTION. — This species has been collected at 8 stations, all off the Isle of Pines. The confirmed bathymetric range is 311–395 m for live-collected specimens. The mean station depth for all specimens is 343.4 m.

ECOLOGY. — This species inhabits soft substrates at depths of 300 to 390 meters, and co-occurs with *Fustifusus pinicola* (Darragh, 1987) at 6 of 8 stations. No identifiable gut contents were found in any of the three specimens examined.

COMPARATIVE REMARKS. — The inclusion of this new species in the genus *Serratifusus* is based

on its distinctive protoconch as well as features of the sculpture, aperture and peripheral keel (DARRAGH, 1969: 69). Adult specimens of *Serratifusus virginiae* closely resemble *Serratifusus craspedotus* (Tate, 1888) (Fig. 13), but differ in being higher-spired and narrower, in having fewer, heavier and longer spines, and in lacking pronounced spiral cords between the suture and shell periphery. Sub-adult specimens (Fig. 12) of *S. virginiae* have proportionally longer siphonal canals, and thus may bear a closer resemblance to *S. stellatus* Darragh, 1969. The latter species differs from *S. virginiae* in having a higher spire, a thicker, stouter siphonal canal, and two or three scaly lirae along the siphonal canal.

Serratifusus lineatus sp. nov.

Figs. 14–16, 20, 26; Table 4.

MATERIAL EXAMINED. — **New Caledonia.** MUSORSTOM 4: stn 156, 18°54.00'S, 163°18.80'E, 525 m. — 15.09.1985: 1 specimen (fragment) 37.7 mm, MNHN. — Stn 164, 18°33.20'S, 163°13.00'E, 255 m, 16.09.1985: 1 specimen 24.5 mm, MNHN. — Stn 181, 18°57.20'S, 163°22.40'E, 355 m, 18.09.1985: holotype, 35.6 mm, MNHN; paratypes 1–3, 31.0 mm, 30.4 mm, 27.7 mm, USNM 860843; paratypes 4–8, 40.9 — 14.3 mm, MNHN; paratype 19, 35.3 mm, AMS; paratype 20, 25.4 mm, NMNZ. — Stn 184, 19°04.00'S, 163°27.50'E, 260 m, 18.09.1985: paratypes 21–31, 43.0 — 10.4 mm, MNHN. — Stn 195, 18°54.80'S, 163°22.20'E, 470 m, 19.09.1985: paratypes 32–40, 32.2 — 19.1 mm, MNHN. — Stn 196, 18°55.00'S, 163°23.70'E, 460 m, 20.09.1985: paratypes 41–46, 30.7 — 17.9 mm, MNHN.

TYPE MATERIAL. — Holotype, MNHN; paratypes 1–3, USNM 860843; paratypes 4–18, MNHN; paratype 19, AMS; paratype 20, NMNZ; paratypes 21–46, MNHN.

TYPE LOCALITY. Western end of Grand Passage, off northwestern New Caledonia, 18°57.20'S, 163°22.40'E, in 350 m. [MUSORSTOM 4, stn 181].

DESCRIPTION. — *Shell* (Figs 14–15) large (to 42 mm), thick, fusiform; spire angle 48°–55°; protoconch (Fig. 20) conical, of 1 1/2 whorls, first whorl deviated from coiling axis by 50°; transition to teleoconch marked by axial ribs with

pronounced knobs along periphery that form short, broad, solid spines by third postnuclear whorl; teleoconch with up to 7 inflated, strongly shouldered whorls; suture adpressed; spiral sculpture almost entirely lacking, limited to faint threads that correspond to spiral lines of dark brown pigment; axial sculpture of 6–8 broad flat solid spines along the shoulder; growth striae fine, sinuate; aperture ovate; outer lip smooth, or with 8–12 weak denticles in large specimens; inner lip smooth; siphonal canal slightly longer than aperture, sinuate; shell color white to light tan, with parallel, dark brown bands that may be solid or interrupted, 3 between suture and periphery, 1 along periphery, 8–9 on body whorl, and 7–8 on proximal 1/2 of siphonal canal; periostracum very thin, yellowish; operculum (Fig. 16), narrow, roughly semicircular, with terminal nucleus and curved median ridge on outer surface.

Animal: One male (holotype) and one female (paratype 1) specimen were dissected. Tissues span 2 3/4 whorls, mantle cavity 1/2 whorl, kidney 1/4 whorl, digestive gland 1 3/4 whorls; animal cream colored, with fine black spots on head, foot; foot broad ($L/W = 1.4$); tentacles short, broad; eyes large, black; mantle edge thin, smooth; osphradium ($L/W = 2.2$) as wide and 2/3 as long as ctenidium, with 110 leaflets above

TABLE 4. *Serratifusus lineatus* sp. nov. Measurements of shell characters. Linear measurements in mm. N = 10.

Character	\bar{X}	Range	SD
Shell length	34.6	27.7-41.1	3.6
Aperture length	10.9	9.3-12.2	0.8
<u>Aperture length</u>			
Shell length	0.32	0.30-0.34	0.02
Siphonal canal length	11.1	8.7-13.5	1.3
<u>Siphonal canal length</u>			
Shell length	0.32	0.30-0.33	0.01
No. whorls teleoconch	6.0	5.5-6.5	0.2
No. varices, body whorl	7.4	7-8	0.5
Spire angle	51.8°	48.0°-55.0°	2.2°

and 92 leaflets below axis; ctenidium with about 350 leaflets; hypobranchial gland narrow, pendant, glandular; rectum broad posteriorly, tapering anteriorly, detaching from roof of mantle cavity just posterior to anus; rectal gland absent; extended proboscis about 0.5 shell length; radula (Fig. 26) short (3.5 mm), narrow (180 μ m), of 98-124 rows of teeth ($n = 3$); lateral teeth tricuspid, outermost cusps longer than basal plates, emanating from near center of basal plates, central cusps narrowest; rachidian teeth tricuspid, cusps of equal length, basal plates deep, rectangular; valve of Leiblein large, anterior to region of esophageal torsion; salivary glands paired, surrounding valve of Leiblein and nerve ring; gland of Leiblein, thin, brown, running along left side of proboscis sheath; stomach simple, tubular, with two widely separated ducts to digestive gland; female pallial oviduct consisting of albumen gland along right wall of kidney,

ingesting gland, elongate capsule gland, and large, pyriform bursa copulatrix situated anterior to capsule gland; male pallial gonoduct consists of closed muscular duct of constant diameter, leading from rear of mantle cavity to base of penis; penis long (2/3 mantle cavity length), dorsoventrally compressed, tapering distally, with short papilla along truncated outer edge.

ETYMOLOGY. — Latin *lineatus*, marked with lines.

DISTRIBUTION. — This species is known only from six stations, all off the western end of the Grand Passage. The confirmed bathymetric range for live-collected specimens is 260-470 m, although fragments and hermit-crab occupied specimens were taken from 255 m to 525 m. The mean station depth for all specimens is 387.5 m, for live-collected specimens 386.3 m.

ECOLOGY. — Little is known of the ecology of this species other than it inhabits rubble bottoms at depths of 260-470 m. No identifiable gut contents were found in any of the three specimens examined.

COMPARATIVE REMARKS. — The shorter siphonal canal, smaller but thicker spines along the shoulder, lack of spiral sculpture, and the characteristic coloration consisting of parallel brown spiral lines serve to distinguish this species from *Serratifusus virginiae*, its only presently known Recent congener.

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REFERENCES

- ALLEN, R. S., 1926. — The geology and paleontology of the Lower Waihao Basin, South Canterbury, New Zealand. *Trans. N. Z. Inst.*, **57**: 265-309.
- BARNARD, K. H., 1959. — Contributions to the knowledge of South African marine mollusca. Part II. Gastropoda: Prosobranchia: Ruchiglossa. *Ann. S. Afr. Mus.*, **45**(1): 1-237.

- BAYER, F. M., 1971. — New and unusual mollusks collected by R/V John Elliot Pillsbury and R/V Gerda in the tropical western Atlantic. *Bull. mar. Sci.*, 21(1): 111-236.
- BEU, A. G., DELL, R. K., FLEMING, C. A., MARWICK, J., MAXWELL, P. A., PONDER, W. F., & POWELL, A. W. B., 1969. — Requests for rulings on works on New Zealand Mollusca by R. S. Allan and H. J. Finlay. Z.N. (S.) 1868. *Bull. zool. Nonn.*, 26(1): 42-50.
- CHAPMANN, F., 1922. — New or little-known fossils in the National Museum. Part XXVI: Some Tertiary mollusca. *Proc. Roy. Soc. Viet.*, 35(1): 1-18, pl. 1-3.
- CLENCH, W. J., 1944. — The genus *Columbarium* in the western Atlantic. *Johnsonia*, 1(15): 1-4.
- CLENCH, W. J., 1959. — The genus *Columbarium* in the western Atlantic. *Johnsonia*, 3(39): 330-331.
- DARRAGH, T. A., 1969. — A revision of the family Columbariidae (Mollusca: Gastropoda). *Proc. R. Soc. Viet.*, 83(1): 63-119, pls 2-6.
- DARRAGH, T. A., 1985. — Molluscan biogeography and biostratigraphy of the Tertiary of southeastern Australia. *Aicheringa*, 9: 83-116.
- DARRAGH, T. A., 1987. — Columbariinae (Gastropoda: Turbinellidae) from Queensland, Australia. *Proc. R. Soc. Viet.*, 99(4): 127-134.
- FINLAY, H. J., 1926. — Further commentary on New Zealand Molluscan systematics. *Trans. N. Z. Inst.*, 57: 320-485, pls 18-23.
- FINLAY, H. J., 1930. — Revision of the New Zealand Shells referred to *Fusinus*. *Trans. N. Z. Inst.*, 61: 259-270, pls 47-49.
- GRABAU, A. W., 1904. — Phylogeny of *Fusus* and its allies. *Smithson. misc. Colln.*, 44(1417): 1-192, pls 1-18.
- HABE, T., 1979. — The western Pacific columbariid species. *Venus*, 38(1): 1-4.
- HARASEWYCH, M.G., 1983. — A review of the Columbariinae (Gastropoda: Turbinellidae) of the western Atlantic with notes on the anatomy and systematic relationship of the subfamily, *Nemouria*. 27: 1-42.
- HARASEWYCH, M.G., 1986. — The Columbariinae (Gastropoda: Turbinellidae) of the eastern Indian Ocean. *J. malac. Soc. Aust.*, 7(3-4): 155-170.
- HARRIS, G. F., 1897. — Catalogue of the Tertiary Mollusca. Part I. Australasia. British Museum (Nat. Hist.) London: xxvi + 407 p., 8 pls.
- MARTENS, E. von, 1901. — Einige neue Meer-Conchylien von der deutschen Tiefsee-Expedition. *Sber. Ges. naturf. Freunde*, Berlin: 14-26.
- MCLEAN, J. H. & ANDRADE, H., 1982. — Large archibenthal gastropods of central Chile: Collections from an expedition of the R/V Anton Bruun and the Chilean Shrimp Fishery. *Contr. Sci. nat. Hist. Mus. L.A. County*, 342: 1-20.
- PONDIR, W.F., 1973. — A review of the Australian species of *Penion* Fischer (Neogastropoda: Buccinidae). *J. malac. Soc. Aust.*, 2(4): 401-428.
- POWELL, A. W. B., 1979. — New Zealand Mollusca, Marine, Land and Freshwater Shells. Collins, Auckland: xiv + 500 p., 82 pls, 119 figs.
- RICHER DE FORGES, B., 1990. — Les campagnes d'exploration de la faune bathyale dans la zone économique de la Nouvelle-Calédonie. Explorations pour bathyal fauna in the New Caledonian economic zone. In: A. CROSNIER (ed.), Résultats des Campagnes MUSORSTOM, Volume 6. *Mém. Mus. natn. Hist. nat.*, (A) 145 : 9-54.
- SPRINGER, V. G., 1982. — Pacific plate biogeography, with special reference to shorefishes. *Smithson. Contrib. Zool.*, 367: 1-182.
- SWAINSON, W., 1840. — A treatise on malacology; or the natural classification of shells and shellfish. A. Spottiswoode, London: viii + 419 p.
- TATE, R., 1888. — The gastropods of the older Tertiary of Australia. Part I. *Trans. R. Soc. S. Aust.* 10: 91-176, pl. 1-13.
- TOMLIN, J. R., 1928. — Reports on the marine mollusca in the collections of the South African Museum. *Ann. S. Afr. Mus.*, 25(2): 313-335.

